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Recreational Use of Public Waterways and the Impact of Water Quality

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Abstract: This study combines routinely collected water quality data from Ireland and an on-site survey of waterway users to evaluate how water quality affects trip days demanded for recreational activities. Water quality measures employed in the analysis include Water Framework Directive (WFD) ecological status as well as several physio-chemical measures. The analysis finds some evidence that higher levels of recreational demand occur at sites with the highest quality metric measures. However, in many of the estimated models there is no statistical association between the water quality metric (e.g. WFD status, BOD, ammonia, etc.) and the duration of the recreational trip. As most sites considered in the analysis have relatively high levels of water quality this result possibly suggests that above an unspecified threshold level that water quality is not a significant determinant of recreational trip duration. Model estimates also reveal a relatively high valuation among participants for water-based recreational activity with an estimate of mean willingness to pay equivalent to €204/day.

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1 Introduction

That people benefit from access to natural and manmade water bodies is well documented (Völker and Kistemann, 2011; Reinhard and Pouli, 2011; Völker and Kistemann, 2013). Increasing the visibility of blue space in urban areas has been associated with lower psychological distress (Nutsford et al., 2016) and there is evidence that exposure to blue spaces during physical activity shortens perceived exercise duration and increases willingness to repeat such exercise in the future (White et al., 2015). Nature-based recreation, aside from the health benefits, has been shown to produce synergistic effects and impact positively on individuals' emotional well-being (Korpela et al., 2014; White et al., 2015). Over 50 percent of the adult population in the developed world frequently access public waterways for recreational purposes (Williams and Ryan, 2004; Environment Agency, 2009; Outdoor Foundation, 2013). Good water quality enhances the enjoyment which recreational water users derive from their chosen activity (Arnold et al., 2013; Wade et al., 2010; Dorevitch et al., 2015, 2011; Aminu et al., 2014; Lee and Lee, 2015) but users do not always recognise poor water quality or its associated risks (Westphal et al., 2008). This has been argued as primarily due to a delay in chronic health impacts and difficulty in perceiving the presence of pollutants (Burger et al., 1993) though Hynes et al. (2008) and Boeri et al. (2012) suggest that the implied health risk may not be an important aspect of a dedicated water sports recreationalist's choice of site, unless the level of water pollution is extreme. Thus good water quality, when it can be perceived by recreational users, contributes positively to utility and is likely to increase demand for recreation activities at public waterways. However, waterway users risk negative health outcomes due to the difficulty of detecting pollutants. Recreational water-users cannot factor poor water quality levels into their perception of an overall recreational experience until a perceptible negative outcome associated with poor water quality arises, such as digestive illness or eutrophication. Aside from health impacts, pollution can reduce the enjoyability of recreational activities by interfering with the user ability to perform an activity, producing offensive odours and reducing the sightliness of a water way site (Food and Agriculture Organisation, 1996; Dodds et al., 2008; Lipton, 2004).

Waterway managers attempt to ensure a high quality experience for recreational water users. One of the ways that managers can measure the impacts of various management actions on recreational user satisfaction is to quantify changes in recreation demand at public waterways sites, given changes in waterway characteristics. This task, like management of waterways, is difficult as waterway users engage in diverse types of recreational activities and will have contrasting preferences for different types of site characteristics. In addition, while some factors affecting recreation demand lie within managers' control, such as access, pricing and facilities, others will not, such as hydromorphological features and weather. While managers may be charged with water quality monitoring and governance, the diversity and extent of water-use (e.g. agricultural, manufacturing, sewage, etc.) mean that waterway managers may ultimately have only limited control of a site's water quality. An understanding of which water quality metrics recreational users are most sensitive towards would enable waterway managers to concentrate resources towards achieving favourable values for those metrics.

This study attempts to estimate how recreational user demand is associated with varying levels of water quality defined by different water quality metrics. This can inform managers about potential public health risks (in the event that users appear to ignore changes in the presence of dangerous pollutants in public waterways) and possibly pre-emptively avoid them. Secondly, it can identify which water quality measures are incorporated into the utility function of recreational users, thus partially driving recreation demand. This information can equip waterway managers with a better understanding of the biological and physico-chemical characteristics which, if successfully controlled, will benefit waterway-user welfare and improve demand for public waterway use. It will also highlight some of the loss in public welfare (and impacts on recreation demand) that could arise in the event of increased pollution of public waterways.

Numerous studies have analysed the impact of water quality on recreational water-use demand. Topics have included angling (Bockstael et al., 1987; Curtis and Stanley, 2016), swimming (Needelman et al., 1995), beach visits (Hanley et al., 2003), boating (Lipton, 2004) and many other water-based recreational activities (Hynes et al., 2008; Gürlük and Rehber, 2008; Paudel et al., 2011; Binkley and Hanemann, 1978). A contribution of this paper is its use of revealed user data to determine which water quality measures users are most responsive towards and whether the response varies by recreational activity. The paper has parallels with Egan et al. (2009) who find recreational anglers to be responsive to the full set of water quality measures used by biologists. The overarching water quality measure in Europe is defined by the European Union's Water Framework Directive (WFD), which requires that water bodies be of good ecological status, a description that covers indicators such as biological quality (i.e. fish, benthic invertebrates, aquatic flora), hydromorphological quality, physical-chemical quality, and chemical status (Directive 2000/60/EC, 2000). There are five status classes within the WFD's classification scheme for water quality: high, good, moderate, poor and bad. These are nominally easy to understand but their usefulness to recreational water users may vary depending on the type of activity water users are involved in. Constituent elements of WFD status, covering a number of ecological and physio-chemical measures, may be more useful for recreational users, but such information is less accessible to the general public. We investigate if recreational use is responsive to WFD status, which comprises biological and physio-chemical states, or whether recreational use is more responsive to chemical status that is potentially more relevant to most water users with the exception of anglers.

This paper employs a travel cost model to estimate a demand function for water and land based recreational users of waterway sites across Ireland. Water quality impacts on recreation demand are evaluated through the inclusion of various water quality metrics in the model's specification. Section 2 of the paper provides a description of the Water Framework Directive (WFD) water quality measurements used in the analysis. Section 3 describes the methodology used for the analysis, specifically the travel cost model, and considers it's suitability for assessing the impacts of changes in water quality on recreation demand. Section 4 describes the socio-economic and other data sources. Section 5 reports the results of the travel cost model, given the inclusion of different water quality measures. The final section provides concluding remarks and suggestions for further work in the area.

2 WFD water quality measures

The first water quality directive of the EEC, the surface waters directive (Directive 75/440/EEC, 1975) focused primarily on the monitoring and protection of drinking water. Upon its inception a series of more general water quality directives were implemented relating to bathing water, dangerous substances, freshwater fish and several other uses. The disjointedness of these various water quality directives eventually culminated in the establishment of the Water Framework Directive (WFD) (Directive 2000/60/EC, 2000). Under the WFD water quality monitoring takes place at diverse water body types (e.g. rivers, lakes, canals, estuaries, coastal waters, etc.). Water pollution can greatly reduce the demand for recreation (Lipton, 2004). Due to the presence of decaying matter, eutrophied water is less suitable for recreational purposes, becoming unsightly and developing slime, weed infestation, and noxious odour from decaying algae.[1] In the extreme case, eutrophication can reduce water oxygen levels, leading to fish kills, significantly impacting recreational fisheries and contributing further to the eutrophication process. Angling and boating activities are physically impeded by eutrophication-driven algal blooms and water users are less likely to swim, boat and fish during algal blooms due to health risks, unfavourable appearance and unpleasant odours (Dodds et al., 2008). Such outcomes can have significant economic impacts. For example in the United States, estimated losses associated with closure of recreational angling and boating sites due to hypereutrophic conditions are between $182-589 million per annum (Dodds et al., 2008).

2.1 WFD Status

The WFD requires that the status of each water body to be assessed across a number of biological and physio-chemical measures producing a overarching WFD ecological status ranging across 5 categories from 'bad' to 'high'. The biological component of WFD status is possibly of most interest to anglers but this will have little relevance to most recreational users. The quality metrics of relevance to most recreational activities (e.g. boating, swimming, etc.) are those surrounding the physio-chemical state of water bodies. Therefore, in addition to investigating how recreational use of waterways is responsive to WFD status we also consider a number of other quality metrics, most of which are used in the overall WFD assessment.

2.2 Dissolved Oxygen and Biochemical Oxygen Demand

Dissolved oxygen (DO) and biochemical oxygen demand (BOD) are inherently related measures of water quality, and indicate whether a water body is in a eutrophied state. The DO level of a water body is the ratio of dissolved oxygen (O_2) to the amount of oxygen that dissolves in the water at a given temperature. Pristine flowing waters will have a saturation level of 100 per cent. At the opposite end of the spectrum, stagnant water that contains organic matter will have significantly decreased DO levels. Higher BOD levels of a water body are associated with lower DO levels. For instance, when large quantities of organic material are present in a water body bacterial uptake of oxygen outstrips the natural replenishment of DO from the atmosphere and by photosynthesis. Eutrophication arises when DO levels become so low that respiring aquatic organisms are unable to absorb sufficient oxygen from the water. While individuals involved in water based activities, such as swimming, are likely to be most sensitive to eutrophic conditions, the demand for all recreational activities near water are likely to be impacted due to impediment of activities, discomfort and visual unpleasantness. Irish regulations giving statutory effect to the WFD and other EU water legislation require waters with 'Good' status have mean BOD levels less than or equal to 1.5 mg/l and that the 95th percentile should be less than or equal to 2.6 mg/l. For DO the 95th percentile should be between 80 and 120% saturation.[2]

2.3 Phosphates

Phosphorous is an essential nutrient required by all organisms for basic life processes. Phosphate carrying pollutants like fertilisers, waste-water, detergents and run off from paved surfaces can exacerbate algal growth in fresh water systems, leading to algal blooms, eutrophication, increased BOD and decreased DO. Phosphates are the limiting factor in fresh water plant and

[1] For example, see `http://www.fao.org/docrep/w2598e/w2598e06.htm`

[2] SI 272/2009 - European Communities Environmental Objectives (Surface Waters) Regulations 2009. Available online: `http://www.irishstatutebook.ie/2009/en/si/0272.html`

algal growth, which makes its control and monitoring critical, if eutrophication is to be avoided. Total phosphates is the sum of orthophosphates, polyphosphates and organic phosphorous.[3] Orthophosphate is the most readily available form for uptake during photosynthesis. High concentrations generally occur in conjunction with algal blooms. For 'Good' WFD status mean orthophosphate levels must be less than or equal to 0.035 mg P/l and the 95th percentile be less than or equal to 0.075 mg P/l.

2.4 Ammonia

Ammonia is generally present in small amounts in natural waters resulting from the reduction of nitrogen containing compounds by microbiological activity. Aquatic organisms are extremely sensitive to deviations away from the natural ammonia level and in particular, the un-ionised form of ammonia a highly toxic to aquatic animals (Eddy, 2005). High ammonia levels produces a noxious odour and is often indicative of sewage pollution. For 'Good' WFD status mean ammonia levels must be less than or equal to 0.065 mg/l N and the 95th percentile should less than or equal to 0.14 mg N/l.

2.5 Faecal Coliform

Faecal coliform originates in human and animal waste and therefore primarily enters a water body through sewage effluent and animal manure run-off. Not all faecal coliform is harmful to humans and the environment but overly high levels in a water body indicate the presence of pathogenic micro-organisms. For example water-borne diseases like giardis and cryptosporidiosis can cause severe digestive illness in humans. Furthermore, the aerobic (and potentially anaerobic) decomposition of organic matter in which faecal coliform is contained reduces the DO saturation level. Measurement of faecal coliform is not undertaken within within the context of WFD monitoring and within our dataset faecal coliform measurement is only available for canal recreation sites.

In summary, though other water quality metrics are assessed as part of WFD water quality monitoring we focus on these measures as being those most likely to capture water conditions that have a direct impact on the quality of the recreational experience. Those impacts may include fish kills, illness or discomfort as well as a reduction in visual aesthetic. The analysis here is not concerned with quantifying these impacts, rather we are interested in quantifying whether the water quality metric level is associated with different levels of recreational activity.

3 Methodology

The travel cost method (TCM) is a frequently used approach for estimating the demand for recreational activities (Martínez-Espiñeira and Amoako-Tuffour, 2008; Egan et al., 2009; Ovaskainen et al., 2012; Hynes and Greene, 2013). It uses data on the travel costs and other expenses to a location where a specific recreation activity takes place. Travel cost is a revealed 'price' for accessing a site for a specific recreational pursuit, and therefore a proxy for the price an individual is willing to pay to engage in the activity. In addition to travel cost, other variables are included in the model to control for different factors which may also partially

[3]Phosphates arise in waterways in organic or inorganic form. Sources of the former include sewage and the breakdown of organic pesticides. Inorganic phosphates are made up of orthophosphates and polyphosphates. Orthophosphates are commonly referred to as reactive phosphorous, and it is this form of phosphorous directly taken up by plant cells to grow. Polyphosphates, commonly used in detergents, are unstable and eventually convert to orthophosphates.

explain variation in an individual's demand for a recreational activity. Such factors can be individual specific, such as income, education or age, or alternative specific, such as site facilities or water quality. The TCM can thus provide not only estimates of demand for recreational activities, but also estimates of the impact of variation in various water quality measures on recreation demand. One would expect a decrease in water quality to be negatively associated with recreation demand at sites where the activity takes place. The TCM allows us to evaluate the extent to which this is the case in practice. Trip duration at a recreation site is modelled as a function of individual and site specific attributes:

$$y_i = f\left(x_i\right) \tag{1}$$

where y_i is a discrete count variable indicating the number of trip days that individual i chooses and x_i is a vector of individual- and site-specific variables including travel cost.

Count models are frequently used to estimate recreational demand models (Martínez-Espiñeira and Amoako-Tuffour, 2008; Ovaskainen et al., 2012; Hynes and Greene, 2013) and are usually based on either a Poisson or negative binomial distribution of recreation demand and follow a theoretical underpinning provided by Hellerstein and Mendelsohn (1993). Surveys of outdoor recreationalists are often conducted on-site, which means only visitors to the site with a positive number of visits are interviewed for the survey. Modelling must account for sample truncation at zero. Additionally the sample is subject to endogenous stratification, which occurs when the survey sample's proportions of site users in terms of frequency of visits does not match population proportions. This arises because frequent visitors to the recreational site have a higher likelihood of being interviewed than infrequent visitors. Carson (1991) was among the first to address the issue of truncation in count models, while Shaw (1988) addresses the issue of endogenous stratification. Englin and Shonkwiler (1995) developed truncated and endogenously stratified recreational demand models based on the Poisson and negative binomial distributions. The Poisson version of the model assumes that the conditional mean and variance of trip demand are equal, which in some instances is likely to be a misspecification. For recreational trip data the variance is often greater than the mean, implying overdispersion in the data. Where overdispersion arises, the negative binomial model is preferred.[4] Following Englin and Shonkwiler (1995), the probability density function for the truncated and endogenously stratified negative binomial model is given by

$$h_i\left(y_i|y_i>0,x_i\right) = \frac{y_i\Gamma\left(y_i+\alpha_i^{-1}\right)\alpha_i^{y_i}\lambda_i^{y_i-1}\left[1+\alpha_i\lambda_i\right]^{-\left(y_i+\alpha^{-1}\right)}}{\Gamma\left(\alpha_i^{-1}\right)\Gamma\left(y_i+1\right)} \tag{2}$$

where $\Gamma\left(\cdot\right)$ is the gamma function, and α_i is the over-dispersion parameter. In estimation we specify α_i as a constant for all values, though less restrictive specifications such as $\alpha_i = \alpha_0/\lambda_i$ (Englin and Shonkwiler, 1995), or $\alpha_i = g(z_i)$ where z_i refers to visitor characteristics (Martínez-Espiñeira and Amoako-Tuffour, 2008) are also feasible. Where the data is found not be to subject to overdispersion a truncated and endogenously stratified poisson model is estimated, the probability density function of which is given by

$$h_i\left(y_i|y_i>0,x_i\right) = \frac{e^{-\lambda_i}\lambda_i^{y^i}}{y_i!(1-exp(-\lambda_i))} \tag{3}$$

Defining λ_i as a function of regressor variables, x_i, converts the model into a regression

[4] Hilbe (2014) discusses the derivation of the negative binomial as a Poisson-gamma mixture model in which the dispersion parameter is gamma shaped. The gamma PDF is pliable, allowing for a wide variety of shapes meaning most count data can be appropriately modelled.

framework. Thus we can model demand as a semi-logarithmic function of price, and independent variables including water quality, such that

$$ln\lambda_i = \beta_0 + \beta_1 x_{1i} + \beta_2 x_{2i} + \dots \quad (4)$$

Given the focus on the impact of water quality on recreational users, the marginal impact of a change in water quality on recreation demand is of interest and is given by $\partial E(y_i|x_i\beta)/\partial x_{wq}$ with x_{wq} being the water quality attribute. In the present application x_{wq} is defined as a discrete rather than a continuous variable and therefore we calculate the impact of water quality as follows

$$E(y_i|x_i\beta)\ |_{x_{wq}=0}\ - E(y_i|x_i\beta)\ |_{x_{wq}=1} \quad (5)$$

For the negative binomial (NB) and Poisson (P) models the change in mean demand for a discrete change in water quality is given by

$$\begin{aligned} NB: &\quad (\lambda_i + 1 + \alpha\lambda_i)\ |_{x_{wq}=0}\ - (\lambda_i + 1 + \alpha\lambda_i)\ |_{x_{wq}=1} \\ P: &\quad (\lambda_i + 1)\ |_{x_{wq}=0}\ - (\lambda_i + 1)\ |_{x_{wq}=1} \end{aligned} \quad (6)$$

4 Data

Recreational water users were surveyed at waterway sites around the Republic of Ireland and Northern Ireland, including lakes, rivers and canals in 2010 and again in 2014. The sampling points were spread across both urban and rural areas with interviews occurring on different days and at different times across the period August-November. Interviewing was weighted towards busier sites and responses were recorded in a face-to-face interview, which took 10 minutes on average to complete. A total of 1632 and 1247 interviews were collected in each year respectively. The dataset is a pooled cross-section rather than a panel. A full description of the survey design and implementation is available in Ipsos MRBI (2010) and Amárach Research (2014).

Users' recreational activities were classified into two user categories; those engaged in a water based recreational activity and those engaged in activities for which access to water is not essential i.e cycling and walking. Observations were excluded in the event that no travel cost data was reported and where trip length exceeded 21 days. For the latter case this was because extended trips are more likely to be associated with multi-purpose visits, not just recreational activity. Various information was collected from survey participants including travel expenditures, the length of the current trip, and socio-demographic data.

Survey data used in the analysis are summarised in Table 1. *TripDays* is the dependent variable in the study and is defined as the number of leisure activity days spent on the current intercepted trip. *DailyCost* is denominated in Euro (€) and reflects the expenditure of a single individual for each day of a trip. It comprises expenditure on items such as fuel, food, beverages and accommodation. From Table 1 we can see that those dedicating their leisure time to water based activities spend slightly more per day than land based visitors. It is worth noting however that this group also spend more days per trip, so spend substantially more on a per trip basis. The variable *Experience* indicates whether an individual rates themselves as somewhat or very experienced in pursuit of their leisure activity. One might expect more experienced practitioners to dedicate more time to their pursuit. The *Prof/Managerial* variable encompasses individuals who work in a professional or managerial capacity in contrast to lower skilled employment. This variable may also be a proxy for higher income and such individuals may have higher levels of demand for recreational activities than those who are either in non-professional employment or are not employed. Individuals from abroad that are holidaying in Ireland during the trip are identified by the variable $VisitIreland$ and may have differing demand for water based leisure activities than Irish based users. An individuals' age and gender can influence their demand for recreation activities and the variables $Aged35+$ and $Male$ are used to control for these characteristics. We also included a dummy variable in our initial analysis indicating which year the survey was administered but found no statistical effect and dropped it from the subsequent models presented here.

Table 1: Summary statistics

Variable	Water based activities		Land based activities		Description
	Mean	Std. Dev	Mean	Std. Dev	
$TripDays$	3.73	3.52	1.47	1.53	Days on current trip
$DailyCost$	38.41	109.11	35.58	129.28	Per day trip cost, €
$Experience$	0.90	0.30	0.83	0.38	=1 if very or somewhat experienced, 0 if unskilled or novice
$Prof/Managerial$	0.62	0.49	0.49	0.5	=1 if professionally employed or managerial, 0 otherwise
$VisitIreland$	0.25	0.43	0.15	0.35	=1 if visiting from outside the island of Ireland, 0 otherwise
$Age35+$	0.62	0.49	0.56	0.5	=1 if aged 35 or above, 0 otherwise
$Male$	0.72	0.45	0.49	0.5	=1 if male, 0 if female

Water quality data for 2010 and 2014 were sourced from monitoring stations within the Republic of Ireland that were proximate to 15 waterway sites where surveys were conducted in the Republic of Ireland.[5] Water quality data were obtained from the Environmental Protection Agency (`http://gis.epa.ie/`) for river and lake sites and data for canal sites was provided by Waterways Ireland (`www.waterwaysireland.org`). A summary of water quality metrics is provided in Table 2. Generally water quality at the sites in our dataset is at a relatively high level. None of the sites are badly polluted. The 'poor' WFD status noted in Table 2 is attributable to low biological classifications and not due to physio-chemical status. Therefore, the analysis here is not comparing recreational activity at polluted versus pristine sites, rather is it is comparing recreational activity across sites that are generally of a relatively high standard. Consequently, the results of the analysis are likely to be more muted than if the dataset also contained sites with relatively low water quality standards.

The relationship between water quality and recreational demand is likely to be non-linear and potentially differ across water quality metrics. However, our model does not purport to be a model of causation, where recreational users are making decisions based on information about water quality. In reality recreational users will have limited information about water quality because only official bathing sites have a statutory requirement to post monitoring results, none of which are in our dataset. Instead, users decisions on recreation demand are based on a range of criteria including their own assessment of water conditions. The models are intended to identify whether users behaviours are responsive to water quality, as indicated by the various quality metrics. We have defined the quality metrics used within the analysis as binary variables indicating above or below average status among the sites in our sample. This approach abstracts from the potential non-linear relationship between water quality and recreation demand. The binary variables are defined as being equal to 1 if the value at the site was greater than or equal to the mean value across all sites in the sample and zero otherwise. For example, a BOD value higher than the mean would have a binary value of 1, indicating inferior quality compared to the mean of all sites. The binary variable for WFD status was defined as equal to 1 if the status was 'poor' and zero if 'moderate' or 'good'.

[5]One exception is WFD status, which was only available for 2010. At the time of the analysis a WFD status had not been assigned for 2014.

Table 2: Water Quality Measures

		Minimum	Mean	Maximum
BOD	mg O_2/l	0.658	1.506	4.408
Ammonia	mg N/l	0.014	0.053	0.506
Phosphates	mg P/l	0.009	0.034	0.080
Faecal Coliform	Count/100ml	20.000	885.828	8800.500
DO	% Saturation	84.125	98.940	119.450
WFD Status		Poor	Moderate	Good

Data points are site specific annual means

5 Results

Travel cost recreation demand models were estimated for both water-based and land-based users controlling both for truncation and endogenous stratification. Negative binomial model results are reported except where evidence of overdispersion was not found, which in our case was generally for the models with lower numbers of observations. In such cases Poisson model results are presented. We estimate each model with only one water quality measure included as an explanatory variable. The first set of models are reported in Table 3 and are specifically for users engaged in water based activities (i.e. angling, boating, etc). Model estimates for land-based activities (e.g. walking, cycling) are reported in Table 4. The dependent variable in all models estimated is $TripDays$, which is the number of days the recreational user spent on the trip. Aside from the travel cost and socio-economic variables included in the regressions, the key variable of interest for this study is the water quality measure, $WaterQ$. In each model presented the definition of $WaterQ$ changes. The water quality metric, which is represented by $WaterQ$, is indicated in the title of each column of coefficients. For column 1 of Table 3, the variable $WaterQ$ is the binary WFD ecological status measure. In column 2, $WaterQ$ represents a binary BOD variable.

5.1 Water Quality

A change in the binary water quality metric variable (i.e. $WaterQ$) from zero to one reflects an increase in the quality metric reading for a site (e.g. a change in the BOD reading from below 1.506 mg O_2/l to above 1.506 mg O_2/l or higher). Consequently, a negative sign is anticipated on the $WaterQ$ variable in each model with the exception of DO, reflecting a decline in recreational demand associated with a relative deterioration in quality or condition. However, as noted earlier, the greater majority of recreational sites under consideration in this analysis all have high levels of water quality, so differences in recreational activity across sites may be difficult to discern. This is reflected in the estimated models. In the estimates for water-based activities the estimated coefficient on $WaterQ$ is statistically significant in the case of WFD status (see model (a) Table 3), which indicates that recreational activity is lower on sites with 'poor' WFD status compared to 'moderate' or 'good' status sites. But for all the other quality metrics (e.g. BOD, ammonia, etc.) the $WaterQ$ coefficient is insignificant, suggesting that demand for water-based recreational demand is not responsive to changes in these measures of water quality. For land-based activities, such as walking and cycling, the $WaterQ$ variable is significant in the case of *Phosphates* and DO only. In both instances the coefficient is positive, which is anticipated in the case of DO, as higher dissolved oxygen levels indicates more pristine waters that may be more attractive to recreational users. *Phosphates* are the limiting nutrient in fresh waters so higher levels will lead to plant growth. In extreme cases high levels of *Phosphates* contribute to eutrophication but that was not a cause for

Table 3: Water Based Activity Days Demanded

Dependent variable: *TripDays*	WFD Status	BOD	Ammonia	Phosphates	Faecal Coliform	DO
Model	Poisson	NB	NB	Poisson	Poisson	NB
	(a)	(b)	(c)	(d)	(e)	(f)
DailyCost	-0.0118***	-0.00589***	-0.00582***	-0.00496***	-0.00578***	-0.00521***
	(-8.85)	(-5.77)	(-6.01)	(-8.33)	(-3.68)	(-5.13)
WaterQ	-0.345***	0.296	-0.511	0.106	14.78	0.0479
	(-3.79)	(1.49)	(-0.88)	(1.61)	(0.02)	(0.32)
Experience	0.315***	0.118	0.150	0.114	-0.109	0.282
	(3.45)	(0.66)	(0.92)	(1.25)	(-0.88)	(1.37)
Prof/Managerial	0.0639	0.124	0.138	0.180***	-0.0203	0.218*
	(0.94)	(1.21)	(1.41)	(3.58)	(-0.25)	(1.82)
VisitIreland	0.863***	0.793***	0.753***	0.711***	0.867***	0.602***
	(13.12)	(7.44)	(7.49)	(14.46)	(9.70)	(4.91)
Age35+	0.701***	0.374***	0.449***	0.375***	0.356***	0.464***
	(8.05)	(3.48)	(4.51)	(6.96)	(3.72)	(3.87)
Male	0.397***	0.152	0.136	0.165***	0.331***	0.0654
	(5.75)	(1.46)	(1.37)	(3.15)	(3.87)	(0.54)
Toilets	2.579**	1.579***	1.031	1.333***	3.357	0.644
	(2.49)	(3.39)	(1.26)	(5.57)	(0.00)	(1.14)
Showers		-0.178	-0.317	-0.221		-0.343
		(-0.39)	(-0.70)	(-1.03)		(-0.77)
Laundry	-0.0237	-0.291	0.347	-0.198	12.63	-0.0622
	(-0.16)	(-1.08)	(0.51)	(-1.53)	(0.01)	(-0.22)
Slipway		-0.237	0.234	-0.281***	-0.583***	
		(-1.55)	(0.41)	(-3.57)	(-5.68)	
ShorePower	-0.157	0.442**	0.767	0.323***		1.559**
	(-1.63)	(2.42)	(1.30)	(3.85)		(2.47)
Parking	-2.031**	-0.785***	-1.250*	-0.693***		-2.156***
	(-1.98)	(-2.62)	(-1.78)	(-4.87)		(-3.09)
FuelPoint	0.218**	0.542***	0.489***	0.416***	0.457***	1.742***
	(2.17)	(2.65)	(3.03)	(4.43)	(4.17)	(2.86)
Constant	-0.138	-2.930**	-2.650**	0.0334	-15.14	-1.340
	(-0.37)	(-2.02)	(-2.13)	(0.17)	(-0.02)	(-1.57)
$ln(\alpha)$		2.685*	2.553**			1.686**
		(1.81)	(2.03)			(2.26)
N	343	613	664	630	233	431
Log-Likelihood	-896.8	-1331.6	-1447.9	-1709.8	-612.6	-955.9
AIC	1819.6	2695.2	2927.8	3449.6	1249.2	1941.7
BIC	1869.5	2765.9	2999.8	3516.3	1290.7	2002.7

t statistics in parentheses. * p<0.10, ** p<0.05, *** p<0.01

Table 4: Land Based Activity Days Demanded

Dependent variable: *TripDays*	WFD Status	BOD	Ammonia	Phosphates	Faecal Coliform	DO
Model:	Poisson	Poisson	Poisson	Poisson	Poisson	Poisson
	(g)	(h)	(i)	(j)	(k)	(l)
DailyCost	0.00779***	-0.00367***	-0.00339***	-0.00355***	-0.00521	-0.00329***
	(2.73)	(-4.87)	(-4.69)	(-4.83)	(-1.03)	(-4.60)
WaterQ	0.00129	-0.0717	0.203	1.626***	-0.0194	1.179***
	(0.00)	(-0.25)	(1.27)	(7.08)	(-0.00)	(4.33)
Experience	0.422	0.901***	0.791***	0.362	0.0158	0.480
	(1.20)	(3.44)	(3.25)	(1.39)	(0.04)	(1.16)
Prof/Managerial	0.766**	-0.324**	-0.336***	-0.259**	0.329	-0.454***
	(2.12)	(-2.52)	(-2.66)	(-2.00)	(1.05)	(-3.19)
VisitIreland	-0.111	0.686***	0.580***	0.730***	0.321	0.644***
	(-0.28)	(4.81)	(4.16)	(5.11)	(0.95)	(4.11)
Age35+	0.213	0.278*	0.302**	0.312**	0.190	0.396**
	(0.59)	(1.94)	(2.12)	(2.17)	(0.63)	(2.41)
Male	0.912***	0.199	0.200	0.119	-0.0668	0.182
	(2.75)	(1.60)	(1.62)	(0.95)	(-0.23)	(1.29)
Toilets	13.66	3.199***	3.223***	4.556***	17.00	0.0182
	(0.02)	(4.25)	(4.50)	(6.07)	(0.01)	(0.02)
Parking	0.572	-1.263***	-1.527***	-2.583***		-2.350***
	(0.00)	(-8.15)	(-8.40)	(-10.22)		(-8.51)
Constant	-17.24	-3.428***	-3.333***	-4.310***	-17.69	0.143
	(-0.01)	(-4.19)	(-4.40)	(-5.53)	(-0.01)	(0.15)
Observations	170	379	422	407	113	309
Log-Likelihood	-98.2	-464.0	-496.2	-448.4	-102.0	-370.3
AIC	216.4	947.9	1012.3	916.7	222.1	760.6
BIC	247.8	987.3	1052.8	956.8	246.6	797.9

t statistics in parentheses. * p<0.10, ** p<0.05, *** p<0.01

Table 5: Angling Days Demanded

Dependent variable: *TripDays*

	WFD Status	BOD	Ammonia	Phosphates
Model:	Poisson	Poisson	Poisson	Poisson
	(m)	(n)	(o)	(p)
DailyCost	-0.0119***	-0.00532***	-0.00481***	-0.00430***
	(-4.39)	(-2.74)	(-3.41)	(-2.59)
WaterQ	0.447	0.602***	-13.56	-0.166
	(0.96)	(2.63)	(-0.03)	(-0.75)
Experience	1.171***	1.644***	1.053***	1.586***
	(6.01)	(5.68)	(5.47)	(5.50)
Prof/Managerial	0.209	0.544***	0.497***	0.510***
	(1.64)	(4.35)	(4.59)	(4.23)
VisitIreland	0.686***	0.611***	0.591***	0.606***
	(5.63)	(5.32)	(5.73)	(5.39)
Age35+	0.240	0.462***	0.399***	0.492***
	(1.64)	(3.19)	(3.21)	(3.39)
Male	0.180	0.112	0.0502	0.0971
	(1.33)	(0.76)	(0.39)	(0.66)
Toilets	14.15	1.142***	-12.09	1.405***
	(0.02)	(3.03)	(-0.03)	(3.61)
Laundry	-0.204	-0.507**	13.00	-0.433*
	(-0.80)	(-2.22)	(0.03)	(-1.80)
Slipway		0.665*	13.64	0.343
		(1.81)	(0.03)	(0.99)
ShorePower	-0.262*	0.368	13.34	-0.277
	(-1.66)	(1.53)	(0.03)	(-1.14)
Parking		0.0617	-12.93	0.642*
		(0.19)	(-0.03)	(1.94)
FuelPoint	0.271*	-0.107	0.0879	-0.259
	(1.68)	(-0.54)	(0.62)	(-1.38)
Constant	-14.56	-3.117***	-2.125***	-3.001***
	(-0.02)	(-6.42)	(-4.54)	(-5.88)
Observations	104	137	157	138
Log-Likelihood	-258.4	-324.8	-382.3	-329.8
AIC	540.8	677.6	792.5	687.5
BIC	572.6	718.5	835.3	728.5

t statistics in parentheses. * p<0.10, ** p<0.05, *** p<0.01

Table 6: Boating Days Demanded

Dependent variable: *TripDays*	WFD Status	BOD	Ammonia	Phosphates	Faecal Coliform	DO
Model:	Poisson	NB	NB	NB	Poisson	NB
	(q)	(r)	(s)	(t)	(u)	(v)
DailyCost	-0.0136***	-0.00677***	-0.00661***	-0.00617***	-0.0103***	-0.00554***
	(-9.39)	(-6.13)	(-6.33)	(-5.99)	(-5.68)	(-5.20)
WaterQ	9.751	0.480**	0.136	0.145	10.22	0.0222
	(0.01)	(2.15)	(0.16)	(1.11)	(0.02)	(0.15)
Experience	0.000656	-0.113	-0.0536	-0.154	-0.404***	0.0967
	(0.01)	(-0.63)	(-0.32)	(-0.84)	(-3.09)	(0.44)
Prof/Managerial	0.000919	0.0402	0.0669	0.0628	-0.0574	0.143
	(0.01)	(0.40)	(0.70)	(0.64)	(-0.66)	(1.22)
VisitIreland	0.861***	0.728***	0.667***	0.706***	0.860***	0.562***
	(12.92)	(7.10)	(6.85)	(6.87)	(9.05)	(4.72)
Age35+	0.832***	0.329***	0.371***	0.389***	0.328***	0.406***
	(9.18)	(3.16)	(3.78)	(3.80)	(3.25)	(3.45)
Male	0.396***	0.216**	0.216**	0.221**	0.422***	0.139
	(5.67)	(2.20)	(2.30)	(2.27)	(4.82)	(1.20)
Toilets	0.317	0.731	1.094	0.917*		0.637
	(0.83)	(1.41)	(0.96)	(1.82)		(1.07)
Showers		-0.173	-0.233	-0.252		-0.226
		(-0.40)	(-0.53)	(-0.58)		(-0.52)
Laundry	-0.204	-0.294	-0.362	-0.282	10.28	-0.192
	(-1.41)	(-1.13)	(-0.38)	(-1.07)	(0.02)	(-0.69)
Slipway	-9.991	-0.275*	-0.422	-0.301**	-0.512***	
	(-0.01)	(-1.90)	(-0.49)	(-2.02)	(-4.72)	
ShorePower		0.411**	-0.0135	0.217		1.199
		(2.15)	(-0.02)	(1.32)		(1.22)
Parking		-0.865***	-0.506	-0.717**		-1.707*
		(-2.77)	(-0.51)	(-2.38)		(-1.67)
FuelPoint	0.294***	0.334	0.445***	0.462**	0.676***	1.484
	(3.87)	(1.55)	(2.67)	(2.41)	(5.87)	(1.54)
Constant	0.403	-0.0553	-0.305	-0.234	-9.060	-0.390
	(1.09)	(-0.10)	(-0.53)	(-0.45)	(-0.01)	(-0.58)
$ln(\alpha)$		0.842**	0.851**	0.914**		0.737*
		(2.41)	(2.55)	(2.55)		(1.89)
Observations	304	518	557	528	185	372
Log-Likelihood	-782.6	-1184.4	-1281.5	-1210.5	-499.0	-862.9
AIC	1589.2	2400.7	2595.0	2453.0	1019.9	1755.8
BIC	1633.8	2468.7	2664.1	2521.3	1055.3	1814.6

t statistics in parentheses. * p<0.10, ** p<0.05, *** p<0.01

concern at the sites analysed during the survey years. The maximum *Phosphates* measure of 0.08 mg P/l (see Table 2) is equivalent to the threshold for WFD 'Good' status, which is the 95^{th} percentile be less than or equal to 0.075 mg P/l.

Unlike land-based activities, the water-based activities captured within the dataset are diverse and require more specialised user equipment (e.g. boats, jet-skiis, canoes, fishing rods, etc.). The nature of interaction with the water also differs considerably between activities. For some activities, such as boating, recreational users are on the water but don't necessarily come into contact with the water. Participants involved in activities such as canoeing, rowing or water-skiing are more likely to have extensive contact with the water and in some instances become submerged. The case of angling is different again in that the biological status of the waters (e.g. fish habitats, stocks) is of relevance. To distinguish whether the responsiveness of recreational users to water quality metric differs among these sub-categories of water-based users we also estimated models conditional to these sub-categories, which are reported in Table 5 for anglers and Table 6 for boating activities.[6] Estimates for other water-based user types are not reported, as the estimates were not satisfactory due to a relatively limited number of observations. Within the angler-specific model estimates in Table 5 the only $WaterQ$ coefficient that is statistically significant is for BOD. The positive sign was not anticipated though a positive sign is consistent with previous research showing that Irish coarse anglers have a preference towards angling sites with lower water quality (Curtis and Stanley, 2016). Coarse fish species are more tolerant of poor water, which may support better fishing. In the boater-specific model estimates in Table 6 BOD is also the only $WaterQ$ coefficient that is statistically significant, as well as being positive in sign.

The significance of the coefficients on $WaterQ$ gives some indication of the responsiveness of recreational users to discrete changes in the various quality metrics, as defined by the binary variables but such coefficients cannot be interpreted as marginal impacts. Instead we use equation 6 to calculate the change in mean recreation days demanded associated with discrete change in the water quality measures. These calculations are evaluated at sample means and reported in Table 7 for the models where the $WaterQ$ coefficient was statistically significant. Their standard errors were calculated by the delta method (Greene, 2012). It is important to restate here that these results do not imply causation, as the dataset comprises a cross-section of recreational trips. The most noteworthy result is from model (a) where the estimated change in mean days demanded of water-based recreational activity is $+1.41$ days for a change in WFD status from 'poor' to 'moderate' or 'good'. However, in the angling- and boating-specific models neither the estimated WFD status coefficient nor the change in mean demand is statistically significant. In the angling-specific model (i.e. model (n)) higher than average BOD levels, where the average is 1.506 mg O_2/l, is associated with angling trips 1.45 days shorter than otherwise. This result is higher than Curtis and Stanley (2016) who find that Irish coarse anglers fishing in higher ecological status waters spend roughly 0.7 days less per trip than those fishing in low status waters. In the boating-specific model estimates the change in mean days demanded associated with the discrete change in BOD levels is not statistically significant.

The results that are potentially most surprising are those relating to faecal coliform, which for our dataset relates only to canal recreation sites. While all faecal coliform is not harmful to humans, its existence in high concentrations may indicate the presence of pathogenic micro-organisms, which pose a risk to health. One could speculate that water-based recreational users

[6] Table 5 does not contain estimates with $FaecalColiform$ or DO due to insufficient observations for model estimation.

avoid sites with high faecal coliform levels but we do not have data to test such a hypothesis. But within the dataset we have recreational users utilising sites with high faecal coliform contamination. The evidence from the models suggest that time spent on site is not responsive to the level of faecal contamination. Hynes et al. (2008) and Boeri et al. (2012) suggest that water quality and the implied health risk may not be an important aspect of a dedicated water sports recreationalist's choice of site, unless the level of water pollution is extreme. The implications for water managers is that in addition to an environmental enforcement issue concerning faecal coliform contamination there is also a public health issue facing some water users.

Overall the estimated models provide some evidence that higher levels of recreational demand at specific sites are associated with the highest quality metric measures but the support is not overwhelming. The lack of compelling evidence may be reflective of the fact that the sites under consideration in this analysis all have relatively high levels of water quality. It may be the case that recreational users are much more responsive to water quality when the gradient of the quality metric is much wider across recreational sites but such analysis was not feasible with the current data. Also, recreational users may have already made site choice decisions based on knowledge of water quality at substitute sites. However, the results echo previous findings on recreational water users from elsewhere. For example, in the United States, Chesapeake Bay boaters willingness to pay for water quality improvements is greatest among boaters most concerned about exposure to toxic chemicals, whereas there is not a significant difference between those concerned with appearance of the water or short-term illness issues (Lipton, 2004). On the other hand Beardmore (2015) find that while issues such as point source pollution, declining fishing quality, or lake shore development, dominated within a minority of users, these same concerns were much less important for others. Nonetheless, the results here do have relevance for policy makers and for waterway practitioners. For instance, as most recreational users appear not be particularly sensitive to higher water quality measures beyond a relatively high but unspecified threshold level it provides further rationale for focusing enforcement and investment efforts on waterways with low quality levels. The results on faecal coliform should also be of concern to those managing recreational water sites. A finding that recreational users are not responsive to an indicator of pathogenic micro-organisms is a public health concern. Though it may be the case that our models have insufficient power to capture recreational users' aversion to waters with high levels faecal coliform. What is clear is that for the majority of recreational water sites (including those in our sample) faecal coliform levels are not measured and recreational users have no objective information on whether the site is contaminated.

Table 7: Change in mean days demands associated with an improvement in quality metric

Activity	Model	Metric	Estimate	s.e.
Water-based	(a)	WFD ecological status	1.41***	0.53
Land-based	(j)	*Phosphates*	-0.59***	0.09
Land-based	(l)	*DO*	0.62***	0.16
Angling	(n)	*BOD*	-1.45**	0.62
Boating	(r)	*BOD*	-0.96	1.04

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

5.2 Other Site Attributes

The estimated models included as explanatory variables dummy variables on the presence of a variety of facilities or services available at recreational sites including toilets, boat slipways, parking, and fuel. Whether a particular site characteristic or facility (e.g. presence of a boat slipway) has importance to a recreational user will depend on the activity. In addition, the site characteristic may be more relevant to the site choice rather than site duration decision. The analysis here focuses on whether site characteristics are associated with the length of time spent on site. The estimated coefficients on these variables vary across the models estimated but there are a number of clear results. The first is that the length of time spent on site is higher at sites with toilet facilities. Surprisingly, we find that site duration is lower at sites that have car parking facilities but caution should be exercised in interpreting this result. It may be that sites with parking facilities are more suited to trips of shorter duration and the analysis is silent on the frequency or number of visitors to such sites. We also find that trips of longer duration occur at sites where fuels are available to purchase and to a lessor extent where a shore-side electricity supply is available. One counter-intuitive result is the negative coefficient on the *Slipway* variable in the boating and water-based models. Not all water-based users, including many boat users, require the use of slipway facilities but it surprising to find that in several models this variable is negatively associated with trip length. In most instances where a slipway is required (e.g. to launch a boat) it should not materially affect the duration of a trip and hence finding statistical insignificance for this variable might be a more reasonable, *a priori*.

5.3 Willingness to pay

The travel cost model allows us to examine the sensitivity of water site users to the cost of engaging in their recreational activity. The estimated coefficient on the travel cost variable, *DailyCost*, is negative and statistically significant in almost all models estimated. The associated price elasticity estimate across all the estimated models varies between -0.03 and -0.14 indicating that users are not that responsive to changes in costs.[7] The model also facilitates the estimation of willingness to pay for recreational activities. Willingness to pay is calculated by adding mean expenditure per day from Table 1 to consumer surplus.[8] Mean consumer surplus (CS) per day given by $-1/\beta_p$, where β_p is the estimated coefficient on the *DailyCost* variable.[9] CS/day estimates are reported in Table 8 and the average across the water-based models is €166/day, with angling somewhat higher at €178/day and boating activities lower at €135/day. The average CS/day across land-based activities is €269/day. It should be noted that while CS/day estimates are higher for land-based activities, the standard error of the estimates are also substantially higher. Using these estimates of CS/day and adding mean expenditures from Table 1 give estimates of mean willingness to pay for a day's recreational activity at a waterway site, which sums to approximately €204/day for water-based activities and €305/day for land-based activities. Both values suggest that recreational activities taking place at the waterway sites included in the study are highly valued by users. Such high valuations are not uncommon in the literature. For example, estimates of per trip consumer surplus or willingness to pay for boating trips in the United States exceed several hundred dollars

[7] The price elasticity is calculated as $\frac{\partial E(y_i|x_i\beta)}{\partial DailyCost}\frac{DailyCost}{E(y_i|x_i\beta)}$ and evaluated at mean values.

[8] Consumer surplus is the difference between the total willingness to pay for a good and the total amount that they actually pay.

[9] Integrating the demand function over the relevant price ranges yields consumer surplus $CS = -\lambda_i/\beta_p$ (Hellerstein and Mendelsohn, 1993) and dividing by the population's mean days demanded yields $-1/\beta_p$ as consumer surplus per day.

(Bockstael et al., 1987; Park et al., 2002; Bhat, 2003). Previous studies of Irish recreational water users include WTP estimates for swimming of approximately €102/trip (Curtis, 2003), white-water kayaking of €152/trip (Hynes and Hanley, 2006), and €371/day for angling (Curtis and Stanley, 2016). Though there are also studies where the WTP estimates are substantially lower. For example, Curtis (2003) estimate WTP/trip of approximately €35 for boating trips in Ireland and likewise Vesterinen et al. (2010) estimate WTP/trip of approximately €23 for swimming, fishing or boating trips in Finland, whereas Barry et al. (2011) estimate a consumer surplus of €22/trip for beach recreational visits in Ireland.

Table 8: Consumer Surplus estimates, €per day

			Water based activities			
Model:	(a)	(b)	(c)	(d)	(e)	(f)
CS	85***	170***	172***	202***	173***	192***
s.e. (CS)	9.6	29.4	28.6	24.2	47.0	37.4
			Angling			
Model:	(m)	(n)	(o)	(p)		
CS	84***	188***	208***	233***		
s.e. (CS)	19.2	68.6	60.9	89.9		
			Boating			
Model:	(q)	(r)	(s)	(t)	(u)	(v)
CS	73***	148***	151***	162***	97***	181***
s.e. (CS)	7.8	24.1	23.9	27.1	17.2	34.7
			Land based activities			
Model:	(h)	(i)	(j)	(k)	(l)	
CS	273***	295***	282***	192	304***	
s.e. (CS)	56.0	62.8	58.4	186.6	66.0	

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

5.4 Socio-economic attributes

The socio-economic explanatory variables in the models enable us to distinguish differences in demand preferences among various types of recreational users. For example, the estimated coefficient on $Male$ is positive and statistically significant in many of the water-based models but less so in the land-based models. The implication is that men spend more time at water-based activities than women but spend similar lengths of time in land-based activities. The coefficient on $VisitIreland$ is positive and significant indicating that international tourists take trips to waterway sites of longer duration that people living in Ireland, irrespective of activity type. The user survey captures two types of waterway visit; those as part of a longer annual holiday and shorter weekend-type trips. People resident in Ireland are more likely to engage in both types of trip, whereas international tourist visitors are less likely to incur such travel expense for short trips. The $Professional$ variable may be capturing an income effect, but the effect is most prominent in the land-based as well as angling regression models. The $ExperienceLevel$ variable is a respondent assessment of their skill or ability level in their recreational activity. We had an *ex ante* intuition that highly skilled individuals spend more time pursuing their activity which would be reflected in trip length (or equally in trip frequency for which we have no data). The results from the angling models in Table 5 show that more experienced anglers undertake fishing trips of longer duration.

6 Conclusion

This paper sought to identify water quality measures that have an association with recreational water users' demand for trip days at key waterway sites around Ireland. The marginal relationship between several measures of water quality and trip-days demanded by land-based and water-based recreational activity site users were estimated. Within the European Union WFD ecological status classification is the primary means for categorising a waterway's quality. The ecological status of a waterway is determined by the lowest status value for the biological and the physio-chemical status calculated for each relevant quality element.[10] A waterway with 'poor' biological status but 'good' physio-chemical status would have an overall WFD ecological status of 'poor'. In terms of impact on the quality of a site for recreational activities a waterway's physio-chemical status is likely to have the greatest impact, with the possible exception of angling where the biological status may be more significant. Consequently, with the exception of anglers we anticipated *ex ante* that recreational users of waterway sites would be more responsive to physio-chemical quality measures than the overall WFD ecological status rating. And additionally we anticipated that recreational demand would be higher at waterway sites with the highest quality metric measures.

Overall the estimated models provide some evidence that higher levels of recreational demand occur at sites with the highest quality metric measures. However, in many of the estimated models there is no statistical association between the water quality metric (e.g. WFD status, BOD, ammonia, etc.) and the duration of recreational trip. As most sites considered in the analysis have relatively high levels of water quality this result possibly suggests that above an unspecified threshold level that water quality is not a significant determinant of recreational trip duration. There is mixed evidence on whether recreational users are more responsive in terms of duration of trip to physio-chemical quality elements versus overall WFD ecological status. Specifically in the case of anglers the results suggest that duration on site was more responsive to BOD level than WFD status. The analysis in the paper is based on the amalgamation of existing datasets that comprise recreational sites with generally high water quality. To make a more complete assessment of the impact of water quality on recreational demand at waterway sites future research should incorporate sites across the full spectrum of water quality measures.

The analysis confirms the high value that users place on waterways as recreational sites. Travel and other costs to recreational sites are substantial, averaging in excess of €35 per person per day for water-based activities with consumer surplus an average of €166/day. In excess of 209,000 adults (approx. 6%) participate in water-based leisure activities at inland waterway sites, on average 10 days per year (Williams and Ryan, 2004). The aggregate associated expenditure for such trips exceeds €1 million per annum, whereas the total value to the participants themselves exceeds €434 million per annum (assuming similar quality across sites). Within our sample the ratio of land-based to water-based recreationalists is 1.6 so the total value of all recreational activity at inland waterway sites is considerably higher. While it was not feasible in the analysis here to demonstrate the potential impact of substantial deterioration in water quality (e.g. via eutrophication) on recreation demand, similar analysis elsewhere (e.g. Dodds

[10] An exception occurs for assigning high status, in which case ecological status is determined by the lowest of the status values obtained for the biological, the physio-chemical and hydromorphological quality elements.

et al. (2008)) suggests that there would be a dramatic decline in recreational demand with an associated loss in value to users.

From the perspective of waterway managers a number of policy implications arise. The first is that there is clear evidence that recreational users spend more time at sites with toilet facilities, which provides support or justification for investment in such facilities at recreational sites. There is similar evidence in the case of provision of fuels and shore-side electricity supply, though these facilities will primarily be of interest to boat users only. The result that recreational users spend less time at sites with car parking facilities requires further research. It may be the case that sites with parking facilities are more suited to trips of shorter duration or alternatively that people engaging in longer duration trips seek solitude from other users, for which the absence of car parking may be a proxy. Failure to find evidence that recreational activity is curtailed at sites with high faecal coliform measurements is likely to be a concern to waterway managers. It is not obvious whether users lack or disregard information on faecal coliform measurements and its risk to health. More generally, faecal coliform measurements are taken at relatively few recreation sites (i.e. just at canal sites) and consideration should be given to extending such measurements to all popular recreation sites.

The paper focuses on demand for recreation time at water sites conditional on the site choice decision. Factors such as water quality or site facilities may have an equally important influence on site choice decisions and consequently the current analysis only partially examines the importance of water quality and other site characteristics in recreation demand. Future research should examine recreational site choice decisions as a function of the site attributes at waterway sites in Ireland.

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